



PATTLE DELAMORE PARTNERS LTD

# NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage 1

New Zealand Defence Force



# NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage 1

• Prepared for

New Zealand Defence Force

• January 2019



PATTLE DELAMORE PARTNERS LTD

Level 4, PDP House

235 Broadway, Newmarket, Auckland 1023

PO Box 9528, Auckland 1149, New Zealand

Tel +64 9 523 6900 Fax +64 9 523 6901

Website <http://www.pdp.co.nz>

Auckland Tauranga Wellington Christchurch



**solutions** for your environment

## Quality Control Sheet

TITLE NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage 1

CLIENT New Zealand Defence Force

VERSION Revised Final – Version 2

ISSUE DATE 21 January 2019


JOB REFERENCE A02684802

SOURCE FILE(S) A02684802R002\_SummaryReportOHA\_Revised Final Version 2.docx


### DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE




James Conway



Aslan Perwick

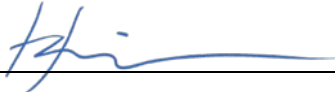
Reviewed by

SIGNATURE



Nerena Rhodes

Approved by



Hamish Wilson

### Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by New Zealand Defence Force and others (not directly contracted by PDP for the work), including Horizons Regional Council, Aecom, Aurecon, Coffey, Golder Associates and Tonkin and Taylor. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of New Zealand Defence Force for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

The information contained within this report applies to sampling undertaken on the dates stated in this report, or if none is stated, the date of this report. With time, the site conditions and environmental standards could change so that the reported assessment and conclusions are no longer valid. Accordingly, the report should not be used to refer to site conditions and environmental standards applying at a later date without first confirming the validity of the report's information at that time.

## Executive Summary

This report documents a sampling investigation undertaken on private properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea ('the site') for the New Zealand Defence Force (NZDF) to investigate the potential for surface water and groundwater contamination relating to the use of per- and poly-fluoroalkyl substances (PFAS) at the site.

Sampling and laboratory analysis of groundwater (from 25 locations), and surface water (from 8 locations) has confirmed the presence of PFAS. At some locations, PFAS exceeded the interim drinking water guidelines (MoH, 2017).

### Groundwater

Groundwater sampling was undertaken over three weeks, from 7 December to 20 December, 2017. Twenty six samples were collected from 25 locations. Of the locations where water use was indicated, 12 of the sample locations are used for potable and/or drinking water supply.

Of the 26 groundwater samples collected:

- ∴ PFAS was reported in 19 samples (73%).
- ∴ Thirteen samples (50%) exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017). Five of these samples were from bores identified as currently used for drinking water supply.
- ∴ Five samples (19%) exceeded the non-potable/contact recreation guideline for the sum of total PFOS + PFHxS.
- ∴ Twelve samples (46%) exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption (this screening value is also applicable to home-grown sheep consumption).
- ∴ Ten samples (39%) exceeded the Stock Watering Only SV for home-grown beef consumption (this screening value is also applicable to home-grown sheep consumption).
- ∴ Sixteen samples (62%) exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Fifteen samples (58%) exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Nine samples (35%) exceeded the Stock Watering Only SV for home-grown egg consumption.

### Surface Water

Surface water samples were collected from 8 stream and pond locations.

### **Drinking Water**

Of the eight surface water samples collected:

- ∴ PFAS was reported in all surface water samples.
- ∴ Two samples (25%) exceeded the non-potable/contact recreation guideline.
- ∴ All eight surface water samples exceeded the Stock Watering and Fodder Irrigation SV variously for home-grown beef, milk and/or eggs.

### **Recommended Stage 2 Investigation Area**

Based on the results of this sampling investigation, and knowledge of the site and surrounding area, follow-up sampling is recommended at all locations sampled during this investigation. In addition, a Recommended Stage 2 Investigation Area is proposed. This area includes additional sample locations that are outside the original Stage 1 Sampling Investigation Area. A detailed assessment of water use within the Stage 2 Investigation Area is also recommended.

## Table of Contents

SECTION	PAGE
<b>Executive Summary</b>	<b>ii</b>
<b>1.0 Introduction</b>	<b>1</b>
<b>1.1 Project Objectives</b>	<b>1</b>
<b>1.2 Scope of Summary Report</b>	<b>1</b>
<b>2.0 Background</b>	<b>1</b>
<b>3.0 Methodology</b>	<b>2</b>
<b>4.0 Guidelines and Screening Values</b>	<b>2</b>
<b>5.0 Quality Assurance/Quality Control</b>	<b>3</b>
<b>5.1 Project Data Quality Objectives</b>	<b>3</b>
<b>6.0 Results Summary and Comparison to Guidelines</b>	<b>4</b>
<b>6.1 Groundwater</b>	<b>4</b>
<b>6.2 Surface Water</b>	<b>6</b>
<b>7.0 Ohakea Groundwater Model Update</b>	<b>8</b>
<b>8.0 Discussion</b>	<b>9</b>
<b>8.1 Groundwater Users</b>	<b>9</b>
<b>8.2 Surface Water Users</b>	<b>10</b>
<b>9.0 Recommendations</b>	<b>11</b>
<b>10.0 References</b>	<b>12</b>

## Table of Tables

Table 1: Environmental and Human Health Guidelines	3
Table 2: Guideline and Screening Value Exceedences – Groundwater Samples (n=26)	6
Table 3: Guideline and Screening Value Exceedences – Surface Water Samples (n=8)	8

## Appendices

- Appendix A: Site Description
- Appendix B: Quality Assurance / Quality Control Summary
- Appendix C: Results Tables – Samples Above LOR Only

## 1.0 Introduction

Pattle Delamore Partners Ltd (PDP), in conjunction with a number of other Environmental Consultancies, has been engaged by the New Zealand Defence Force (NZDF) to undertake an external sampling campaign to investigate the potential for surface water and groundwater contamination by the use of per- and poly-fluoroalkyl substances (PFAS) at properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea.

Sample results for landowners of adjacent properties have been reported in individual landowner reports, with recommendations regarding ongoing use of the water. This summary report provides a summary of these water sampling results in the context of the entire investigation area, along with recommendations for follow up work.

### 1.1 Project Objectives

The key project objectives for this sampling investigation were:

- ∴ To assess groundwater and surface water from sites adjacent to Base Ohakea and determine if PFAS compounds are present,
- ∴ To compare the concentrations of PFAS compounds present against interim drinking water guideline values and applicable screening values, and
- ∴ Provide preliminary estimates of PFAS plume extent in groundwater.

### 1.2 Scope of Summary Report

The scope of this report involved:

- ∴ Collecting representative samples of groundwater and surface water from adjacent sites and analyses of these samples for PFAS.
- ∴ Comparison of the laboratory results to guideline and screening value criteria.
- ∴ Update of the Ohakea Groundwater Model with the new results.
- ∴ Provide recommendations for ongoing monitoring and sampling.

## 2.0 Background

PFAS compounds, such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), are a group of manufactured chemicals used since the 1950s. PFAS have been and continue to be used in a wide range of industrial and commercial products including aqueous film forming foam (AFFF) used for fighting fuel fires. Recently PFAS have gained increasing scientific and regulatory interest due to their widespread use, their environmental persistence and

because some PFAS (primarily PFOS and PFOA) display bioaccumulative and toxic properties to humans and wildlife (CONCAWE, 2016).

PFAS are emerging contaminants. NZDF is investigating the potential for contamination of ground and water associated with the use and storage of AFFF containing PFAS at its camps and bases. Investigations at Ohakea have identified PFAS in the soil and water on the base.

Ohakea is surrounded by pastoral land predominantly used for grazing cattle and dairy farming. Shallow (and deep) groundwater is used relatively extensively on properties surrounding the base for water supply. A description of the geology and hydrogeology for the area is contained within Appendix A.

### 3.0 Methodology

Groundwater and surface water sampling was undertaken in groundwater supply wells and in surface water at selected locations adjacent to the base following the methodology outlined in the *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force* (PDP, 2017a) and the guidance documents referenced therein.

Sampling was undertaken over three weeks, from 7 December to 20 December, 2017. All samples were sent toASUREQuality laboratories, Wellington under standard chain of custody procedures and were analysed for their PFAS suite.

### 4.0 Guidelines and Screening Values

The interim guidelines for drinking water and non-potable water/contact recreation currently used in New Zealand to compare with the water sample data collected during this project are presented in Table 1. Additional screening criteria have been prepared by NZDF consultants EnRisks, for water supply for animals/products grown and consumed at home (home-grown produce).

Guidelines are provided for three PFAS compounds only. These compounds are known to be associated with certain types of AFFF. Henceforth results are discussed for these three compounds only. Results for the full analytical suite of 28 PFAS are available in the laboratory reports. These are provided in a separate electronic file.



Table 1: Environmental and Human Health Guidelines					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Drinking Water	0.07 µg/L	0.56 µg/L	-	-	MoH <sup>1</sup> , AGDoH <sup>2</sup>
Non-potable Water / Contact Recreation	0.7 µg/L	5.6 µg/L	-	-	AGDoH <sup>2</sup>
Stock Watering Only (home grown consumption)	-	Beef 150 µg/L	Beef 0.1 µg/L	Beef 0.1 µg/L	EnRisks <sup>3</sup>
	-	Milk 30 µg/L	Milk 0.02 µg/L	Milk 0.02 µg/L	
	-	Eggs 4 µg/L	Eggs 0.2 µg/L	Eggs 0.09 µg/L	
Stock Watering and Fodder Irrigation (home grown consumption)	-	Beef 60 µg/L	Beef 0.06 µg/L	Beef 0.05 µg/L	EnRisks <sup>3</sup>
	-	Milk 14 µg/L	Milk 0.008 µg/L	Milk 0.008 µg/L	
<p>Notes:</p> <ol style="list-style-type: none"> <li>1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS.</li> <li>2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia.</li> <li>3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed.</li> </ol>					

## 5.0 Quality Assurance/Quality Control

Due to the very low detection limits of PFAS required for this investigation, a robust quality assurance/quality control (QA/QC) programme was required.

### 5.1 Project Data Quality Objectives

The project data quality objectives (DQOs) were to:

1. Determine the presence or absence (less than 0.005 µg/L) of PFASs in groundwater from groundwater bores.
2. Determine the presence or absence (less than 0.005 µg/L) of PFASs in surface water.

To determine if the DQOs were met, the internal QA/QC function ('QAChecker'), in the environmental database software ESdat, was used to calculate relative percent differences between sample duplicates and to check for detections of PFAS in blanks.

The results of the QA/QC check indicate that all samples meet the DQOs. This is with the exception of one rinsate blank and one trip blank, both of which had very low concentrations (<0.0025 µg/L) of the compound 6:2 FTS detected. These concentrations are close to the limit of reporting (LOR) for 6:2 FTS, therefore applying the estimated measurement uncertainty to the results, the numerical values are not considered to be statistically significantly different from the LOR. Furthermore, 6:2 FTS is not one of the target compounds for this investigation.

A summary of the QA/QC check is provided in Appendix B. Additional information relating to the QA/QC results can be provided upon request.

## 6.0 Results Summary and Comparison to Guidelines

A total of 26 groundwater samples (from 25 locations) and eight surface water samples were collected. Note, sample GW19 and GW30 were collected from the same location, on separate days. This was because sample GW19 was initially thought to be unrepresentative of the aquifer conditions.

Summary tables for groundwater and surface water results above the LOR are provided in Appendix C. An electronic file containing the laboratory reports is also appended.

### 6.1 Groundwater

A summary of the groundwater sample results is presented below along with a comparison of the results to the interim drinking water guidelines, the non-potable guidelines, and the screening values for stock watering and fodder irrigation developed by EnRisks (2017). Screening values defined for beef would also be conservative for the consumption of home-grown sheep meat (EnRisks, 2017). Currently there is no information of the applicability of these screening values to the consumption of home-grown goat meat.

#### 6.1.1 Drinking Water

Of the 26 groundwater samples collected (from 25 locations):

- ∴ PFAS was detected in 19 samples (73%).
- ∴ Thirteen samples (50%) exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017).

- ∴ Six samples (23%) returned concentrations of the sum of total PFOS + PFHxS above the LOR but below the interim drinking water guideline (MoH, 2017).
- ∴ Seven samples (27%) were reported as less than the LOR for the sum of total PFOS + PFHxS.
- ∴ PFOA was reported in 18 samples (69%), however no samples were found to exceed the interim drinking water guideline for PFOA.

#### 6.1.2 Non-potable, Stock Watering and Fodder Irrigation

- ∴ Five of the 26 groundwater samples (19%) exceeded the non-potable/contact recreation guideline for the sum of total PFOS + PFHxS.
- ∴ Twelve samples (46%) exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption.
- ∴ Ten samples (39%) exceeded the Stock Watering Only SV for home-grown beef consumption.
- ∴ Sixteen samples (62%) exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Fifteen samples (58%) exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Nine samples (35%) exceeded the Stock Watering Only SV for home-grown egg consumption.

#### 6.1.3 Groundwater Results Summary

A summary of the groundwater results compared to the relevant drinking water and non-potable guidelines, and the stock watering and fodder irrigation screening values is provided in Table 2.

<b>Table 2: Guideline and Screening Value Exceedences – Groundwater Samples (n=26)</b>			
<b>Guideline</b>	<b>Number Exceeding the Relevant Guideline</b>	<b>Percent Exceeding the Relevant Guideline</b>	<b>Source</b>
Interim Drinking Water	13	50%	MoH <sup>1</sup> , AGDoH <sup>2</sup>
Non-potable Water / Contact Recreation	5	19%	AGDoH <sup>2</sup>
<b>Site Specific Screening Value – Beef Consumption (home grown)</b>			
Stock Watering and Fodder Irrigation	12	46%	EnRisks <sup>3</sup>
Stock Watering Only	10	38.5%	EnRisks <sup>3</sup>
<b>Site Specific Screening Value – Milk Consumption (home grown)</b>			
Stock Watering and Fodder Irrigation	16	61.5%	EnRisks <sup>3</sup>
Stock Watering Only	15	58%	EnRisks <sup>3</sup>
<b>Site Specific Screening Value – Egg Consumption (home grown)</b>			
Stock Watering Only	9	35%	EnRisks <sup>3</sup>
<b>Notes:</b> <ol style="list-style-type: none"> <li>1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS.</li> <li>2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia.</li> <li>3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017.</li> </ol>			

## 6.2 Surface Water

A summary of the surface water sample results is presented below. It is likely (based on the results of a recent survey) that surface water sampled within the investigation area is not used for drinking water. Therefore results have been compared to the non-potable/contact recreation guideline and the stock watering and fodder irrigation screening values.

### 6.2.1 Non-potable, Stock Watering and Fodder Irrigation

Of the eight surface water samples collected:

- ∴ Two samples (25%) exceeded the non-potable / contact recreation guidelines for the sum of total PFOS + PFHxS.
- ∴ Four samples (50%) exceeded the Stock Watering and Fodder Irrigation SV for home-grown beef consumption.
- ∴ Two samples (25%) exceeded the Stock Watering Only SV for home-grown beef consumption.
- ∴ All eight samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Seven samples (88%) exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Three samples (38%) exceeded the Stock Watering Only SV for home-grown egg consumption.

### 6.2.2 Surface Water Results Summary

A summary of the surface water results compared to the relevant non-potable guidelines, stock watering and fodder irrigation screening values, is provided in Table 3.

<b>Table 3: Guideline and Screening Value Exceedences – Surface Water Samples (n=8)</b>			
<b>Guideline</b>	<b>Number Exceeding the Relevant Guideline</b>	<b>Percent Exceeding the Relevant Guideline</b>	<b>Source</b>
Non-potable Water / Contact Recreation	2	25%	AGDoH <sup>2</sup>
<b>Site Specific Screening Value – Beef Consumption (home grown)</b>			
Stock Watering and Fodder Irrigation	4	50%	EnRisks <sup>3</sup>
Stock Watering Only	2	25%	EnRisks <sup>3</sup>
<b>Site Specific Screening Value – Milk Consumption (home grown)</b>			
Stock Watering and Fodder Irrigation	8	100%	EnRisks <sup>3</sup>
Stock Watering Only	7	87.5%	EnRisks <sup>3</sup>
<b>Site Specific Screening Value – Egg Consumption (home grown)</b>			
Stock Watering Only	3	37.5%	EnRisks <sup>3</sup>
<p><i>Notes:</i></p> <ol style="list-style-type: none"> <li><i>Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS.</i></li> <li><i>Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia.</i></li> <li><i>Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017.</i></li> </ol>			

## 7.0 Ohakea Groundwater Model Update

The current results from the external campaign have been used to update the 3D numerical groundwater flow model PDP developed for NZDF using the proprietary software ‘Visual MODFLOW Version 4.6.0’ (PDP, 2017b).

Of the 25 groundwater bore locations, 14 bores had information on bore depth, which has been used to assume a sample depth. The bores were generally very shallow, with only 3 bores having a recorded depth greater than 20 m below ground level (bgl). For the remaining 12 bores without depth information, it has been assumed that these samples are also from bores <20 m bgl. It should be noted that the ‘shallow’ groundwater system at Ohakea as a whole, is considered to extend to ~50 m bgl. Sample depth is a very important aspect for interpreting the results. This is due to the hydrogeological understanding that shallow

groundwater is likely to contain higher concentrations of PFAS than deeper groundwater.

The results from this investigation - along with the previously completed on-base sampling and initial technical assessments of the hydrogeological system - have been used to inform an estimated shallow groundwater plume extent for total PFOS + PFHxS. Two estimates have been developed:

- ∴ 0.07 µg/L Plume Extent – displays the estimated extent of total PFOS + PFHxS shallow groundwater concentration  $\geq 0.07$  µg/L (the interim drinking water guideline concentration).
- ∴ Above Detection PFAS Plume Extent - displays the estimated extent of total PFOS + PFHxS shallow groundwater concentration above the LOR. Equates numerically to: 0.001 µg/L to  $< 0.07$  µg/L.

#### 7.1.1 Estimated Plume Limitations

Due to their physiochemical properties, the fate and transport of PFAS is complicated and poorly understood. As such, extrapolation of these results, particularly to locations down-gradient, is uncertain and may not represent the actual conditions present. On this basis, any assessment of risk to receptors located outside the current investigation area is limited.

## 8.0 Discussion

### 8.1 Groundwater Users

#### 8.1.1 Drinking Water

Results from this surface water and groundwater sampling investigation indicate that the 'plume' of PFAS contaminated groundwater extends for a distance of at least 3 to 3.5 km from the boundary of Base Ohakea in a general south to south west direction. In particular, the southern portion of the investigation area contains a number of bores with concentrations of PFAS exceeding the interim drinking water guideline (as indicated by groundwater samples from GW2, GW13a, GW16, GW17, GW19/GW30, GW20 and GW21).

Currently 12 groundwater bores have been confirmed as being used for drinking and/or potable water supply, however information on water use is incomplete at the time of reporting. Five of these bores (GW5, GW6, GW13a, GW16 and GW17) contain concentrations of total PFOS + PFHxS that exceed the interim drinking water guideline. All these bores are located south of the Base, at distances ranging from approximately 600 m to 2 km from the Base boundary.

Three bores (GW9, GW10 and GW18) used for potable supply reported concentrations of total PFOS + PFHxS above the LOR, but below the drinking water guideline. These bores are located to the north and west of Base Ohakea.

Four bores (GW7, GW14, GW25 and GW26) used for potable supply reported concentrations of total PFOS + PFHXS below the LOR. These bores are located to the west and southwest of the site. Bore GW7, located to the west of the Base, did not contain PFAS at reportable concentrations, despite being approximately 400 m down gradient of a number of bores with concentrations of PFAS above the drinking water guideline. This may be due to bore GW7 being a deep bore (57 m) and that PFAS is currently restricted to shallower groundwater.

#### 8.1.2 Non-potable, Stock Watering and Fodder Irrigation

Sample results have been compared to the site specific screening values (EnRisks, 2017) (refer Table 1). These screening values are used to assess the risk of on-farm consumption of farm grown products (e.g. homekill) only (which are assumed to drink groundwater), which is a more conservative exposure pathway given the potential for consumption of larger quantities of beef, milk or eggs from a single animal. These screening values are not relevant for produce supplied to the general market. Screening values defined for beef would also be conservative for the consumption of sheep meat (EnRisks, 2017).

Sixteen samples exceeded the screening value for home-grown milk consumption and twelve samples exceeded the screening value for home-grown beef consumption. Of these samples, one site indicated water use for stock only and six indicated water use for stock and irrigation.

Nine samples exceeded the screening value for home-grown eggs. The extent to which chickens are raised at these locations is not known.

## 8.2 Surface Water Users

PFAS has been reported in all eight of the surface water samples collected confirming surface water is an important pathway (mechanism for PFAS to migrate) for PFAS at Ohakea. The extent to which surface water is used either recreationally is not well understood and further assessment of surface water use is recommended.

In general, the surface water samples are located on streams that have been identified as the main stormwater discharge points for Base Ohakea (e.g. samples SW13 and SW20 in the south and samples SW11 and SW12 in the west). An exception to this are the four surface water samples collected from ponds in the southwest of the investigation area (SW14, SW17, SW18 and SW19). These samples are approximately 4 km from the Base boundary and contain elevated concentrations of total PFOS and PFHxS. Groundwater samples collected up gradient returned concentrations below the LOR suggesting the pond water is not sourced from groundwater. At the time of sampling the overland flow path feeding these ponds was dry. Most PFAS are not volatile; hence the elevated concentrations recorded here may be a result of concentrated PFAS in the remaining pond water following evaporation of pond water.



## 9.0 Recommendations

Based on the results of this investigation, follow up sampling is recommended for all surface water and groundwater locations sampled in this investigation. In addition, an expanded investigation area is recommended, as is the collection of detailed information on water use for all Stage 2 sampling locations. The recommended 'Stage 2 Investigation Area' is approximately defined by the current 'PFAS Plume Estimate', however this area could increase based on the results of the next round of water sampling.

The proposed schedule for follow-up sampling is outlined below.

- ∴ Bores on all properties within the estimated 'Stage 2 Investigation Area' are re-sampled or added to the sampling campaign (whichever applicable).
- ∴ Surface water sampling during low-flow conditions (where possible) is completed on all streams/drains within the 'Stage 2 Investigation Area'. Sample frequency is recommended at approximately 1 per 1 km of stream/drain reach – but may vary from stream to stream. Further sampling may also be required dependant on results.
- ∴ Collation and assessment of the above mentioned additional sampling results and commensurate updates to the interpretative assessment and further recommendations (if needed).

A minimum of three rounds of sampling is recommended approximately as follows:

- ∴ February – to coincide with annual low-flow conditions.
- ∴ Late March/April – to coincide with 'first flush' wet weather during which time, higher concentrations of PFAS may be encountered.
- ∴ August/September – to coincide with annual groundwater high.

## 10.0 References

- AGDoH, 2017. *Final Health Based Guidance Values for PFAS for use in site investigations in Australia*. The Department of Health, Australian Government, Canberra, Australia. Sourced 15/05/2017  
[https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)
- CONCAWE, 2016. *Environmental Fate and Effects of Poly- and Perfluoroalkyl Substances (PFAS)*. Report No. 8/16. 23 June 2016.
- EnRiskS, 2017. *Livestock Uptake Modelling and Screening Criteria Development for PFAS, draft*. Revision C. Environmental Risk Sciences Pty Ltd. 1 November 2017.
- MoH, 2017. *Poly-fluoroalkyl substances (PFASs), also called perfluoroalkyl substances (PFASs) draft*, Ministry of Health November 2017.
- PDP, 2017a. *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force*. Pattle Delamore Partners Ltd. December 2017.
- PDP, 2017b. *NZDF Ohakea – Groundwater Assessment and PFAS Fate Prediction*. Pattle Delamore Partners Ltd. November 2017.

## Appendix A

Site Description

1

## Appendix A: Site Description

### Geology and Hydrogeology

The Geological Map of the Taranaki Area (Townsend et al., 2008) indicates that the area is underlain by Late Pleistocene river deposits; poorly to moderately sorted gravel with minor sand and silt underlying terraces and includes minor fan deposits and loess.

Regional groundwater flow direction is expected to be in a west to southwest direction towards the Rangitikei River and the west coast. Close to the Rangitikei River, local groundwater will be primarily influenced by the river and therefore flow direction is inferred to be towards the Rangitikei River.

Based on the geology, it is possible that variations in groundwater level may be due to discontinuous lenses of low permeability silt and clay layers acting as an aquitard beneath coarser sand and gravel layers.

### Topography and Hydrology

The regional topography near the Rangitikei River is dominated by a succession of paleo river terraces that step down to the current level of the river. As such, the majority of the area is flat; except in the west of the investigation area where the land slopes steeply to the lower river terrace approximately 8 m below.

The Rangitikei River borders the north and west boundary of the investigation area. The Makowhai Stream runs along the eastern boundary of the investigation area, eventually discharging to the Rangitikei River. Numerous open drainage ditches run through the investigation area, particularly alongside the roads and eventually discharge in to the Rangitikei River (in the south east this is via the Makowhai Stream).

### Reference

Townsend, D.; Vonk, A.; Kamp, P.J.J. (compilers), 2008: *Geology of the Taranaki area: scale 1:250,000*. Lower Hutt: GNS Science. Institute of Geological & Nuclear Sciences 1:250,000 geological map 7. 77 p.

## Appendix B

Quality Assurance / Quality Control  
Summary

**ESDAT QA Checker**

**Project:** Ohakea Combined Database

**Filter:** SDG in('AO2744105','AO27144105','AO2774105','AO2744105')

**Overview Summary**

[Count of Samples](#)

[Count of Results](#)

**Holding Times**

**Blanks**

[Detects in Blanks \(2\)](#)

**Duplicates**

[Field and Interlab Duplicates](#)

Lab Duplicates with high RPDs (0)

Duplicate Samples with incorrect or missing Parent Samples (0)

**Lab Control Samples**

SDG's without a Laboratory Control Sample (0)

Laboratory Control Samples, Error > 25% (0)

[Contents](#)

Count of Samples

<b>Matrix Type</b>	Water
<b>First Sample Date</b>	7/12/2017
<b>Last Sample Date</b>	20/12/2017
<b>Sampling Period (days)</b>	14
<b>Number of Samples Submitted</b>	83
<b>Number of Non QA Samples Submitted</b>	35
<b>Number of Field Blanks</b>	10
<b>Number of Trip Blanks</b>	19
<b>Number of Rinsates</b>	10
<b>Number of Field Duplicates</b>	9
<b>Number of Trip Spikes</b>	0
<b>Number of Lab Duplicates</b>	6
<b>Number of LCSs</b>	0
<b>Number of CRMs</b>	0
<b>Number of Method Blanks</b>	0
<b>Number of Storage Blanks</b>	0
<b>Number of Matrix Spikes</b>	0
<b>Number of Matrix Spike Dupes</b>	0

[Contents](#)

Detects in Blanks

SDG	Lab_Report_Number	Matrix_Type	SampleCode	Field_ID	Sampled_Date-Time	Sample_Type	Compound	Prefix	Result	Extraction_Date
AO2744105	990601	Water	AO2744105_OHA_ADJ_GWBF_1_191217	OHA_ADJ_GWBF_1_191217	19/12/2017	Rinsate	6:2 FTS		2.4 ng/L	28/12/2017
AO2744105	989630	Water	AO2744105_OHA_ADJ_SWAZ_1_151217	OHA_ADJ_SWAZ_1_151217	15/12/2017	Trip_B	6:2 FTS		1.6 ng/L	23/12/2017



## Appendix C

Results Tables – Samples Above LOR  
Only

**Table C-1: Groundwater Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only - Drinking Water <sup>1</sup>**

	Sum PFHxS+PFOS (1) <sup>3</sup>	PFOA
Limit of Reporting	0.001	0.001
Interim Guidance Level for Drinking Water, MoH 2017 <sup>2</sup>	0.07	0.56

Sample Name	Location	Date Sampled	Sum PFHxS+PFOS (1) <sup>3</sup>	PFOA
OHA_ADJ_GW1_1_071217	GW1	7/12/2017	0.084	0.0072
OHA_ADJ_GW2_1_071217	GW2	7/12/2017	0.74	0.098
OHA_ADJ_GW3_1_081217	GW3	8/12/2017	0.062	0.0065
OHA_ADJ_GW5_1_111217	GW5	11/12/2017	0.073	0.009
OHA_ADJ_GW6_1_111217	GW6	11/12/2017	0.13	0.014
OHA_ADJ_GW9_1_121217	GW9	12/12/2017	0.015	0.0011
OHA_ADJ_GW10_1_121217	GW10	12/12/2017	0.0083	0.0016
OHA_ADJ_GW12_1_131217	GW12	13/12/2017	0.0043	-
OHA_ADJ_GW13_1_131217	GW13	13/12/2017	0.61	0.056
OHA_ADJ_GW13a_1_131217	GW13a	13/12/2017	0.16	0.011
OHA_ADJ_GW16_1_141217	GW16	14/12/2017	0.93	0.12
OHA_ADJ_GW17_1_141217	GW17	14/12/2017	0.46	0.05
OHA_ADJ_GW18_1_141217	GW18	14/12/2017	0.037	0.0018
OHA_ADJ_GW19_1_141217	GW19	14/12/2017	0.71	0.084
OHA_ADJ_GW20_1_141217	GW20	14/12/2017	0.83	0.11
OHA_ADJ_GW21_1_141217	GW21	14/12/2017	0.81	0.11
OHA_ADJ_GW23_1_141217	GW23	14/12/2017	0.0071	0.0042
OHA_ADJ_GW29_1_191217	GW29	19/12/2017	0.37	0.034
OHA_ADJ_GW30_1_201217	GW30	20/12/2017	0.65	0.092

Statistical Summary		
Number of Results	19	18
Minimum Concentration	0.0043	0.0011
Maximum Concentration	0.93	0.12
Median Concentration	0.16	0.024
Number of Guideline Exceedances	13	0

Notes:

1. Values in µg/L (parts per billion).
2. Interim Guidance Level for Drinking Water, MoH 2017. Sourced from Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
3. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

- Less than the laboratory level of reporting

Table C-2: Groundwater Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only - Non-potable, Stock Water and Fodder Irrigation <sup>1</sup>

	Sum PFHxS+PFOS (1) <sup>4</sup>	PFOA	Total PFHxS (3) <sup>5</sup>	Total PFOS (7) <sup>5</sup>
Limit of Reporting	0.001	0.001	0.001	0.001
Non Potable Water / Contact Recreation Guideline <sup>2</sup>	0.7	5.6	No GL	No GL
SSSV - Beef Consumption (home grown) (Stock Watering and Fodder Irrigation) <sup>3</sup>	No GL	60	0.06	0.05
SSSV - Beef Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	150	0.1	0.1
SSSV - Egg Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	4	0.2	0.09
SSSV - Milk Consumption (home grown) (Stock Watering and Fodder Irrigation) <sup>3</sup>	No GL	14	0.008	0.008
SSSV - Milk Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	30	0.02	0.02

Sample Name	Location	Date Sampled				
OHA_ADJ_GW1_1_07122017	GW1	7/12/2017	0.084	0.0072	0.05	0.034
OHA_ADJ_GW2_1_071217	GW2	7/12/2017	0.74	0.098	0.6	0.14
OHA_ADJ_GW3_1_081217	GW3	8/12/2017	0.062	0.0065	0.053	0.009
OHA_ADJ_GW5_1_111217	GW5	11/12/2017	0.073	0.009	0.064	0.0086
OHA_ADJ_GW6_1_111217	GW6	11/12/2017	0.13	0.014	0.077	0.052
OHA_ADJ_GW9_1_121217	GW9	12/12/2017	0.015	0.0011	0.013	0.002
OHA_ADJ_GW10_1_121217	GW10	12/12/2017	0.0083	0.0016	0.0041	0.0042
OHA_ADJ_GW12_1_131217	GW12	13/12/2017	0.0043	-	0.0043	-
OHA_ADJ_GW13_1_131217	GW13	13/12/2017	0.61	0.056	0.41	0.2
OHA_ADJ_GW13a_1_131217	GW13a	13/12/2017	0.16	0.011	0.14	0.018
OHA_ADJ_GW16_1_141217	GW16	14/12/2017	0.93	0.12	0.29	0.64
OHA_ADJ_GW17_1_141217	GW17	14/12/2017	0.46	0.05	0.18	0.28
OHA_ADJ_GW18_1_141217	GW18	14/12/2017	0.037	0.0018	0.032	0.0053
OHA_ADJ_GW19_1_141217	GW19	14/12/2017	0.71	0.084	0.54	0.17
OHA_ADJ_GW20_1_141217	GW20	14/12/2017	0.83	0.11	0.49	0.34
OHA_ADJ_GW21_1_141217	GW21	14/12/2017	0.81	0.11	0.5	0.31
OHA_ADJ_GW23_1_141217	GW23	14/12/2017	0.0071	0.0042	0.0018	0.0053
OHA_ADJ_GW29_1_191217	GW29	19/12/2017	0.37	0.034	0.15	0.22
OHA_ADJ_GW30_1_201217	GW30	20/12/2017	0.65	0.092	0.5	0.15

Statistical Summary

Number of Results	19	18	19	18
Minimum Concentration	0.0043	0.0011	0.0018	0.002
Maximum Concentration	0.93	0.12	0.6	0.64
Median Concentration	0.16	0.024	0.14	0.096
Number of Guideline Exceedances	5	0	16	14

Notes:

- Values in µg/L (parts per billion).
- Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
- Site specific screening values from *Livestock Uptake Modelling and Screening Criteria Development for PFAS*. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed.
- Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
- Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

No GL	No Guideline or Screening Value
-	Less than the laboratory level of reporting

Table C-3: Surface Water Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only - Non-potable, Stock Water and Fodder Irrigation <sup>1</sup>

	Sum PFHxS+PFOS (1) <sup>4</sup>	PFOA	Total PFHxS (3) <sup>5</sup>	Total PFOS (7) <sup>5</sup>
Limit of Detection	0.001	0.001	0.001	0.001
Non Potable Water / Contact Recreation Guideline <sup>2</sup>	0.7	5.6	No GL	No GL
SSSV - Beef Consumption (home grown) (Stock Watering and Fodder Irrigation) <sup>3</sup>	No GL	60	0.06	0.05
SSSV - Beef Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	150	0.1	0.1
SSSV - Egg Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	4	0.2	0.09
SSSV - Milk Consumption (home grown) (Stock Watering and Fodder Irrigation) <sup>3</sup>	No GL	14	0.008	0.008
SSSV - Milk Consumption (home grown) (Stock Watering Only) <sup>3</sup>	No GL	30	0.02	0.02

Sample Name	Location	Date Sampled				
OHA_ADJ_SW11_1_121217	SW11	12/12/2017	4.5	0.76	2.2	2.3
OHA_ADJ_SW12_1_131217	SW12	13/12/2017	4.2	0.69	2.4	1.8
OHA_ADJ_SW13_1_141217	SW13	14/12/2017	0.049	0.0083	0.016	0.033
OHA_ADJ_SW14_1_151217	SW14	15/12/2017	0.11	0.016	0.092	0.017
OHA_ADJ_SW17_1_151217	SW17	15/12/2017	0.094	0.017	0.07	0.024
OHA_ADJ_SW18_1_151217	SW18	15/12/2017	0.059	0.012	0.041	0.018
OHA_ADJ_SW19_1_151217	SW19	15/12/2017	0.037	0.0068	0.029	0.0077
OHA_ADJ_SW20_1_201217	SW20	20/12/2017	0.13	0.017	0.04	0.091

Statistical Summary

Number of Results	8	8	8	8
Minimum Concentration	0.037	0.0068	0.016	0.0077
Maximum Concentration	4.5	0.76	2.4	2.3
Median Concentration	0.102	0.0165	0.0555	0.0285
Number of Guideline Exceedances	2	0	8	7

Notes:

1. Values in µg/L (parts per billion).
2. Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
3. Site specific screening values from *Livestock Uptake Modelling and Screening Criteria Development for PFAS*. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed.
4. Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
5. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

No GL	No Guideline or Screening Value
-------	---------------------------------